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SR5: Assessing the spatial representativeness of air quality sampling points

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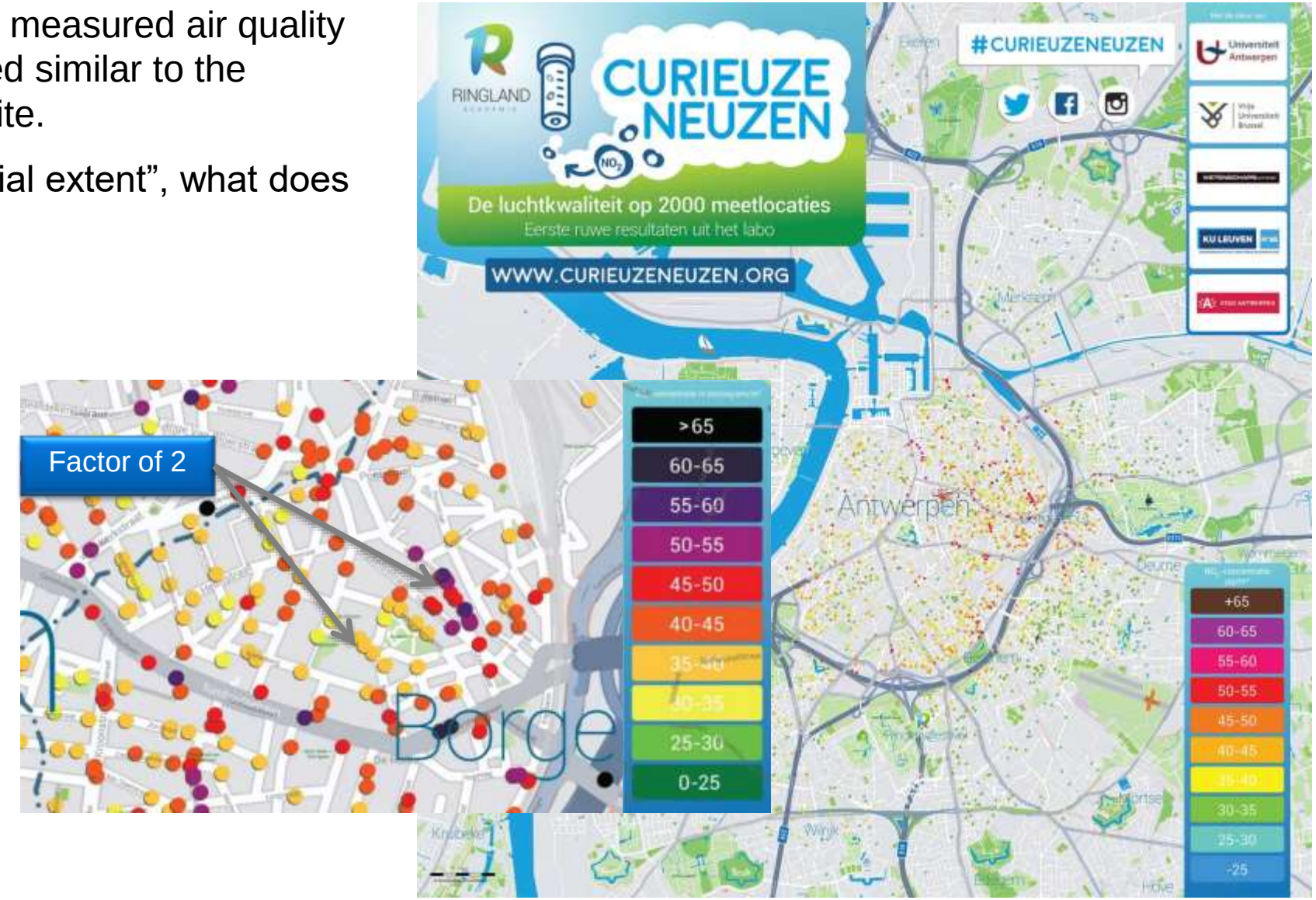
Assessing the spatial representativeness of air quality sampling points

1. What is spatial representativeness?
2. Project overview
3. Key results and findings
4. Relevance to UK Local Authorities

What is spatial representativeness ?

- The spatial extent over which a measured air quality concentration can be considered similar to the observation at the monitoring site.
- How to define or interpret “spatial extent”, what does “similar” mean?
- Representativeness of stations varies with the pollutant species considered, so what might be a representative area for the station for one pollutant may not be the same for another at the same station.



Why is it relevant?

- Health Impacts
  - To calculate the number of people exposed to the air pollution measured by a monitoring station to estimate the health impact of air pollution.

- Requirements in **IPR (e-Reporting)*:**
  - Establish how many citizens are affected by exceedances of limit and target values
  - Identify the Area of Exceedance and the number of people exposed
  - Determine the appropriateness of the network design (evaluation of representativeness and site classification)

- Imminent update of the AQD

* Commission Implementing Decision on the reciprocal exchange of information and reporting on ambient air quality (2011/850/EU)

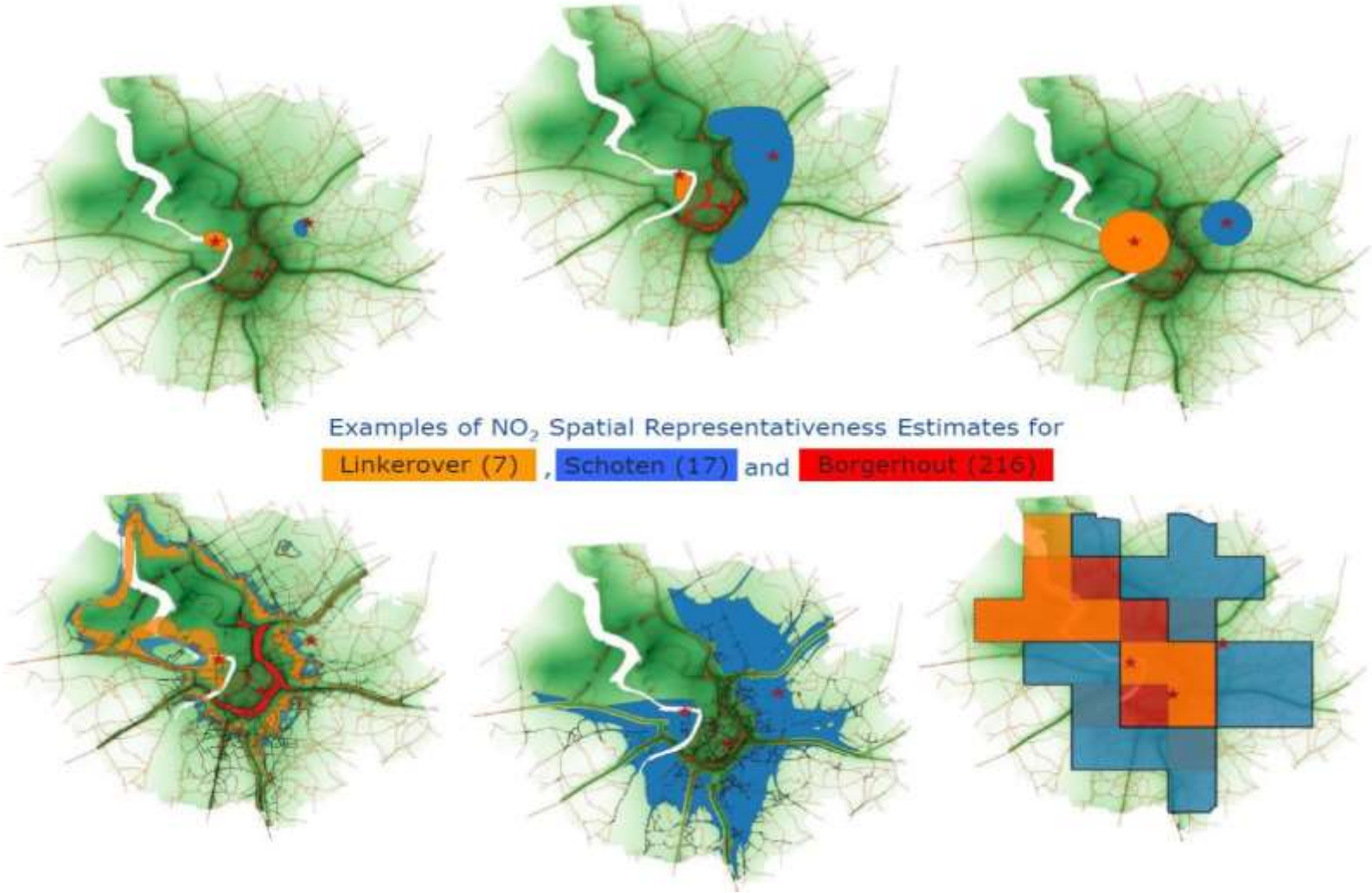
Define SR by assessment needs

Assessment needs investigated:

1. Exceedance Situation Indicators
   a) Estimate of the **surface area** where the level was above the environmental objective,
   b) Estimate of the **length of road** where the level was above the environmental objective,
   c) Estimate of the total resident **population** in the exceedance area

2. SR areas of monitoring sampling points
   a) Facilitate the **configuration** of a representative **monitoring network**,
   b) Identify sampling points that are suitable for **model calibration** and **validation**,

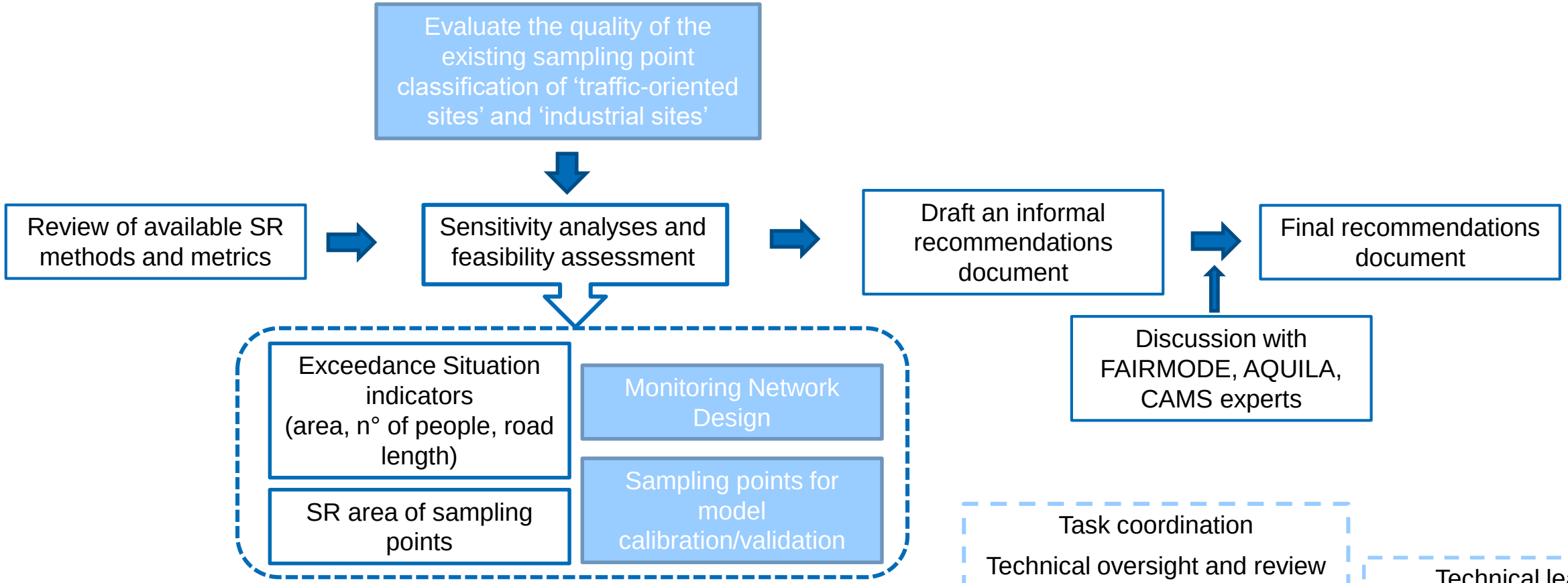
Six different modelling results for the SR of three stations in Antwerp



Kracht, O. et al (2017). Spatial representativeness of air quality monitoring sites: Outcomes of the FAIRMODE/AQUILA intercomparison exercise

Project Overview

Objective: Underpin recommendations on the spatial representativeness of sampling and related modelling and reporting.



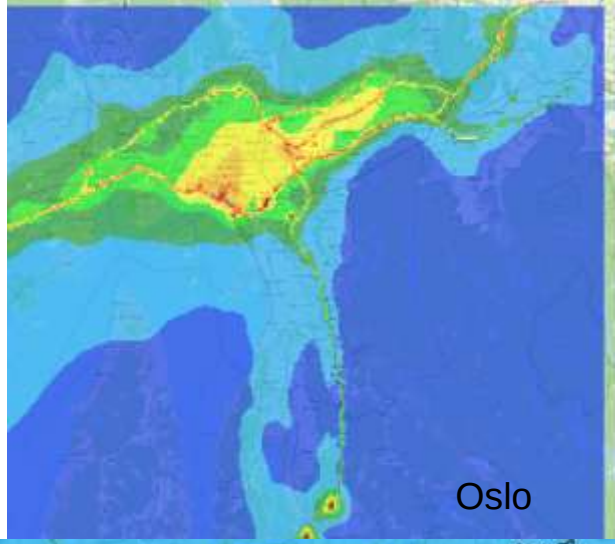
Tiered approach

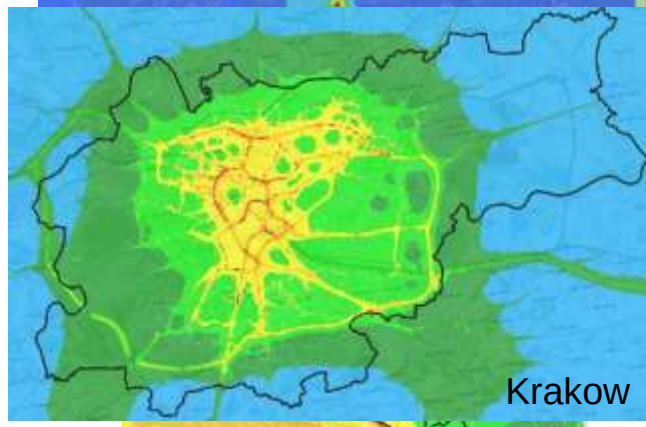
Tier	Description
Tier 1	Expert opinion that provides a qualitative assessment of spatial representativeness made on the basis of local knowledge of the monitoring site Relatively simple “distance to source” considerations.
Tier 2	Add source and dispersion related information. Based on the combination of monitoring site characterisation with proxy data (geographical via GIS data or temporal via time series analysis to determine the variability of AQ concentrations in the area surrounding the monitoring site).
Tier 3	Use of air quality dispersion modelling to link information on sources and dispersion conditions around the monitoring site adding possibly also information of long-range transport influences. Provides an explicit spatial representativeness area based on modelling information, with the recognised limitations that models and their input data may have.
Tier 4	More comprehensive approach with additional detailed observations around the monitoring site. Reducing the uncertainty inherent to any modelling application with the help of additional observations.

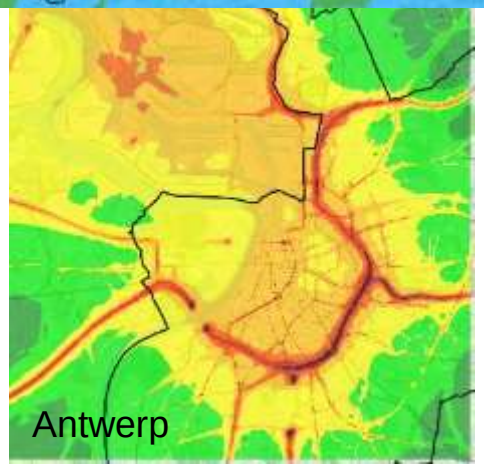
Workstream 1- SR area & Exceedance Situation Indicators

Sensitivity tests

- Three cities: Oslo, Antwerp, Krakow
- Two pollutants: NO_2, PM_{10}
- Urban Background and traffic locations
- Utilised existing analyses done using the different tiered methodologies for Tiers 1, 2 and 3







- Additional analyses to provide insights into specific details
  - Relevance of street canyons
  - (Dis)contiguity
  - Similarity criterion
  - Threshold value

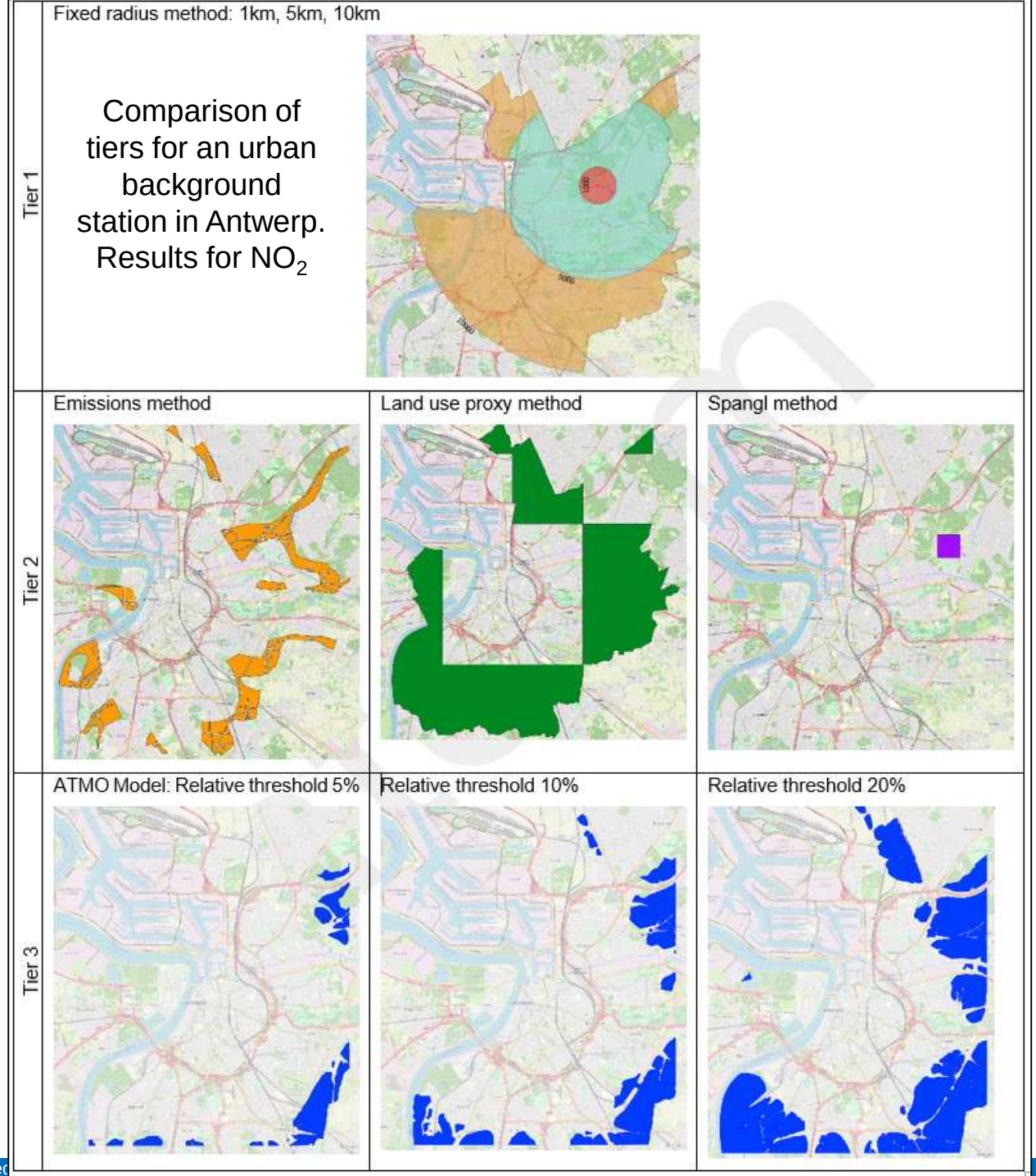
Not discussed – please see report

SR area of sampling points

Overall recommendation:

Higher Tier approaches provide the most realistic assessment of SR (Tier 3 and above)

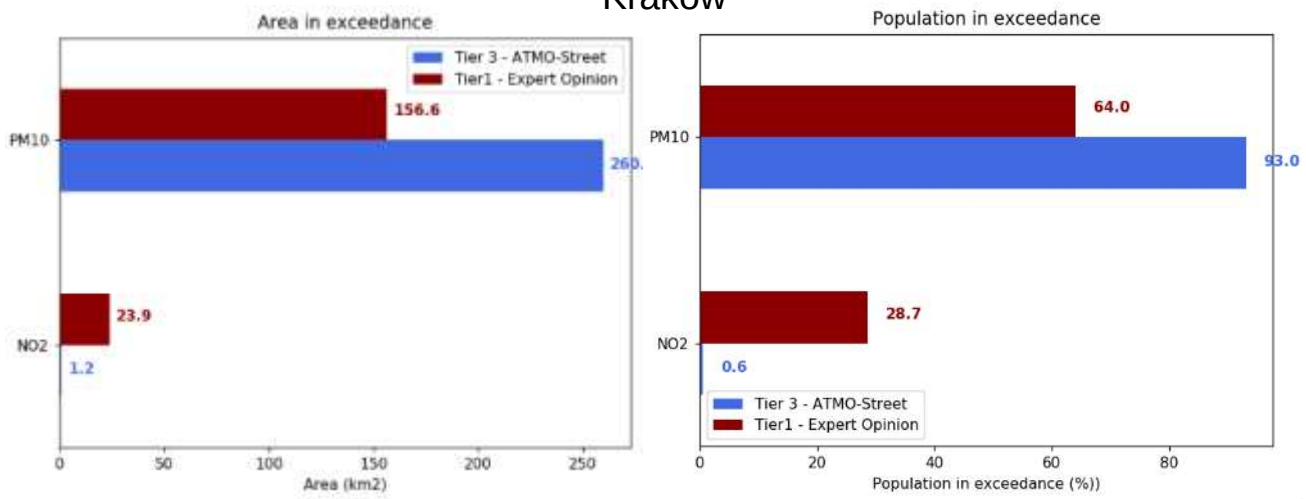
Comparison of tiers for an urban background station in Antwerp. Results for NO_2



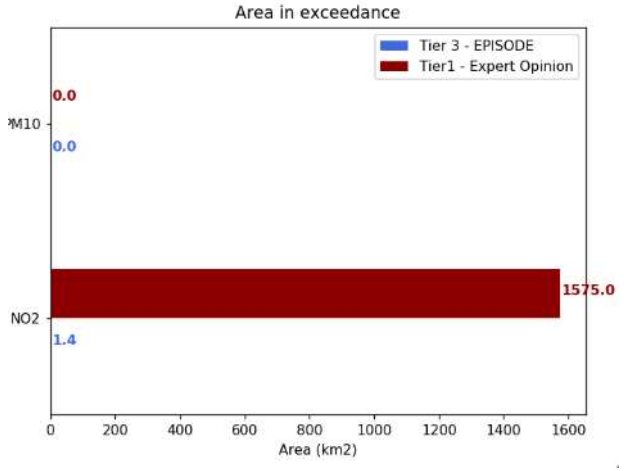
Exceedance situation indicators

Comparison of the exposure indicators reported by the countries (Tier 1 expert opinion) with those obtained using the ATMO-Street/EPISODE simulations

Krakow



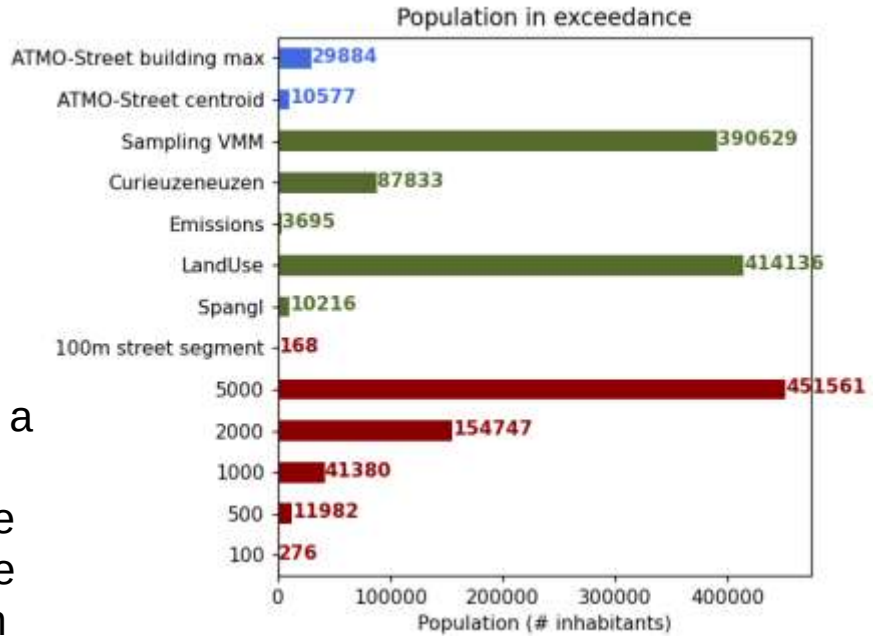
Oslo

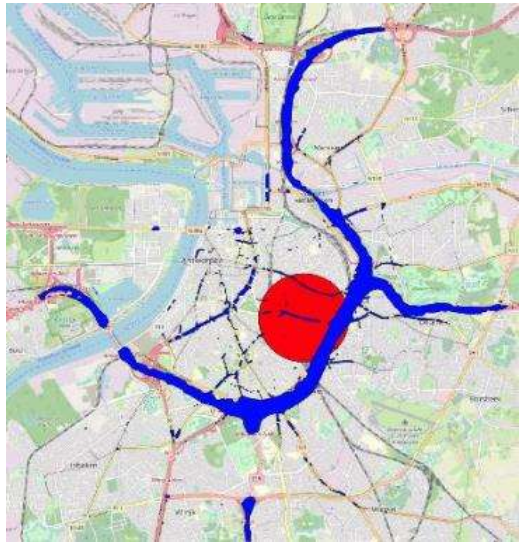


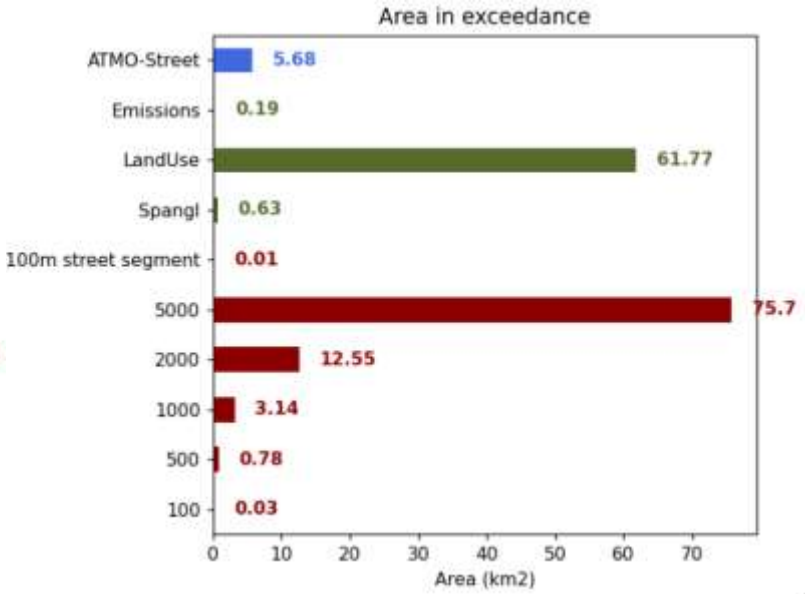
Exceedance situation indicators

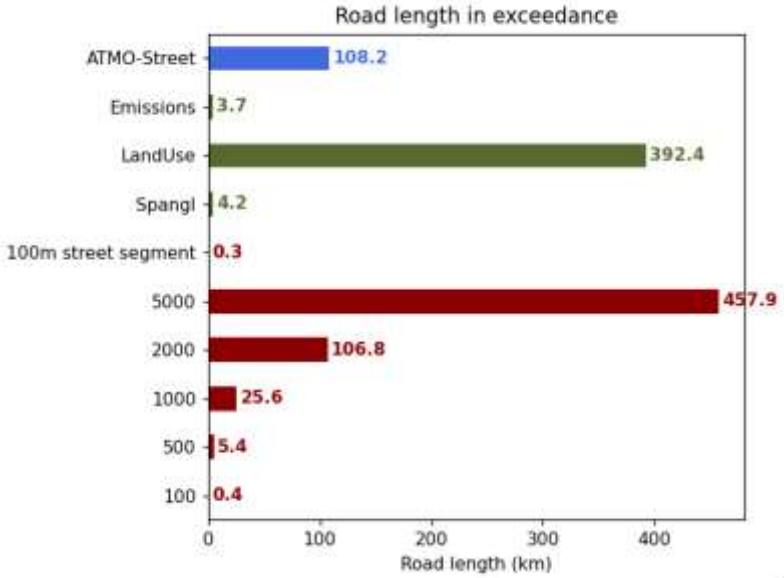
NO_2 exceedance situation indicators obtained using the different Tiers for Antwerp.

The map shows results for a fixed radius method with radius equal to 1 kilometre (red) and the results of the ATMO-street model chain (blue).



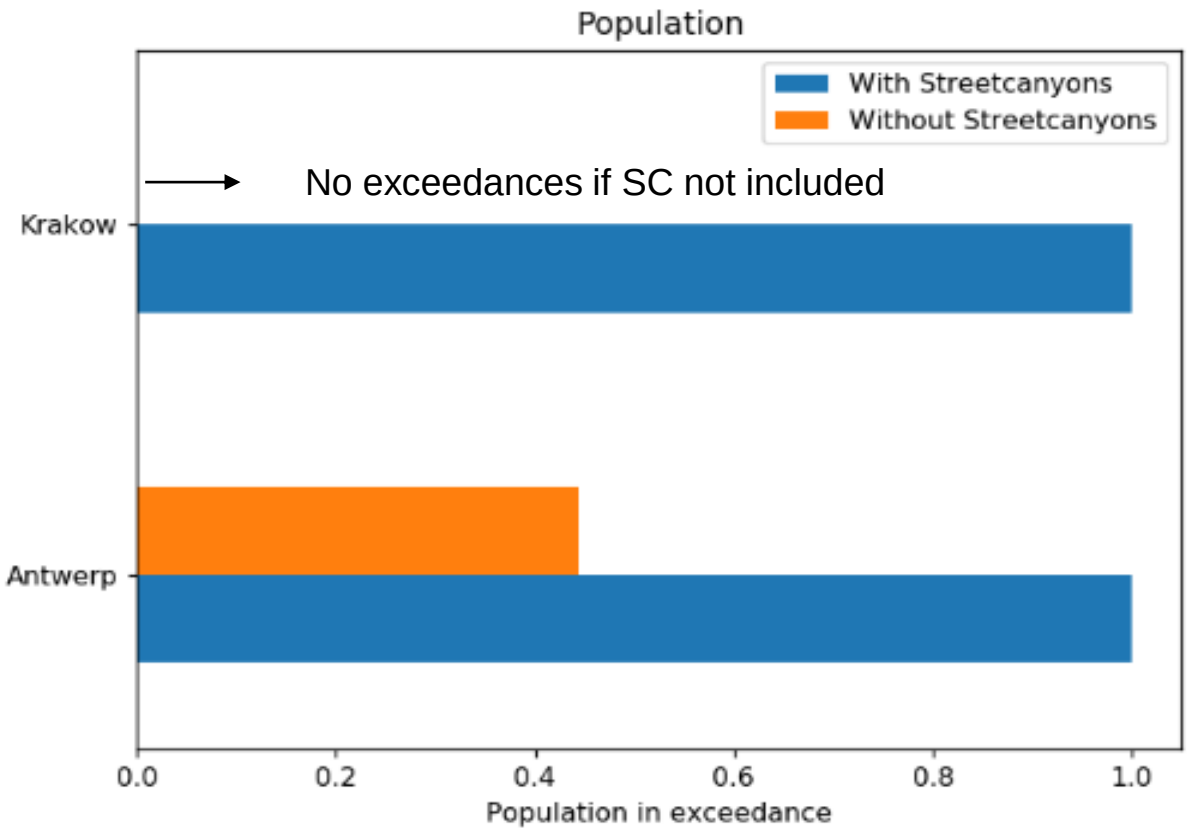




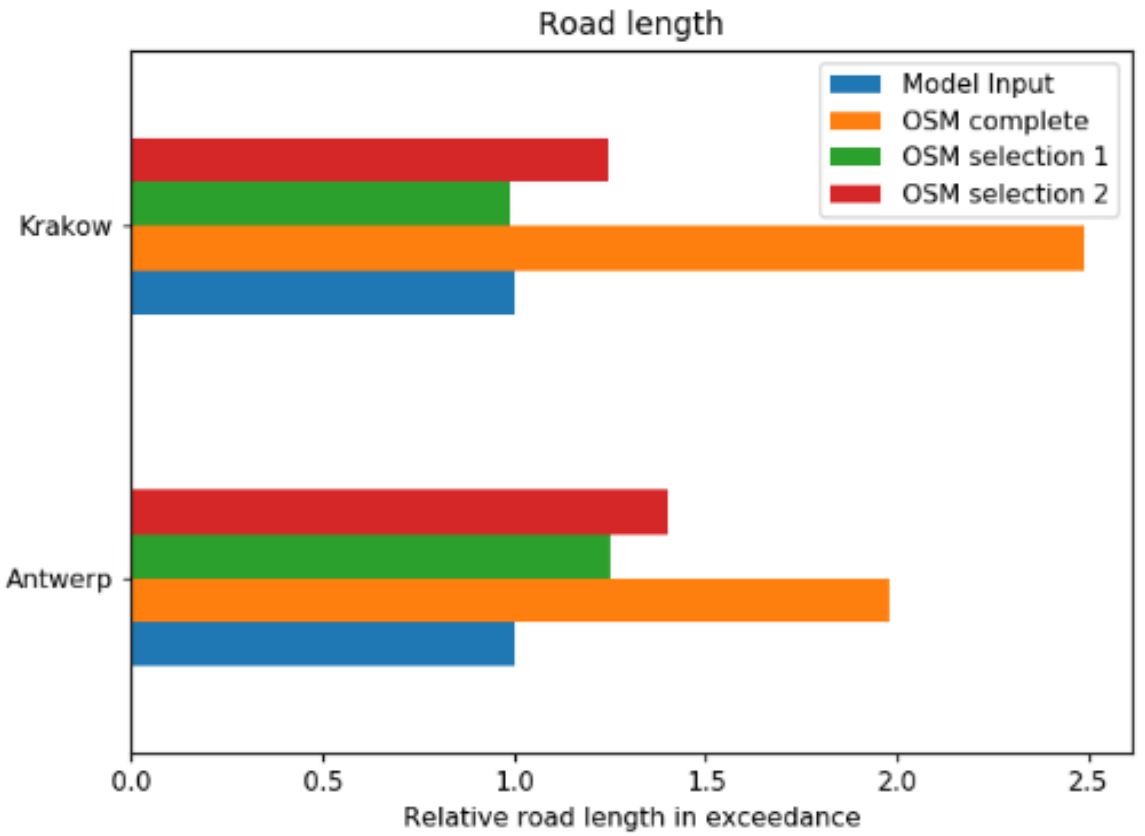


Exposure situation indicators: Sensitivity to input data and methodology

Importance of **street canyon effects** when computing population in exceedance



Importance of **road map** when computing road length in exceedance



Suitability of Tiered approach

		SR area of sampling points (based on annual mean concentrations)	Exceedance Situation indicators (area, n° of people, road length)
Tier 1	Expert Opinion	• Only for (urban) background stations • Not recommended for traffic stations • Unclear for industrial stations	• Not recommended
Tier 2	Proxy Information	• Only for (urban) background stations • Not recommended for traffic stations • Unclear for industrial stations	• Not recommended
	Sampling campaigns	• For all station types, if the campaign is well-designed and contains enough sampling locations	• Can be used for number of people exposed to exceedances, if the campaign is well-designed and contains enough sampling locations • Unclear for other indicators due to an absence of available methods
Tier 3	Geographically explicit modelling	• For all station types, if the model is fit-for-purpose	• For all indicators, but sensitive to methodologies and model errors
Tier 4	Modelling complemented with dedicated measurements	• For all station types, if the methodology is fit-for-purpose	• For all indicators, but sensitive to methodologies and model errors

Workstream 2 - Feasibility tests for network design & model validation

- The current air quality monitoring network in Europe has been designed inter alia following the Tier 1 methodologies
- Significant gaps have been identified in the evaluation and reporting of the area of representativeness of the monitoring sampling - lack of guidance and tested methodologies
- Feasibility tests in Antwerp and Oslo on the potential of using higher level Tier approaches as screening methods to determine the quality of the monitoring network to answer the following three questions:
  - Are there any redundancies in the monitoring network in the city area? (where more than one monitoring station is located within the same SR area)
  - Are there any significant outliers in the monitoring network?
  - Are all hot-spot areas covered by the current monitoring network?

Application of siting criteria & sampling point classification
Network optimization

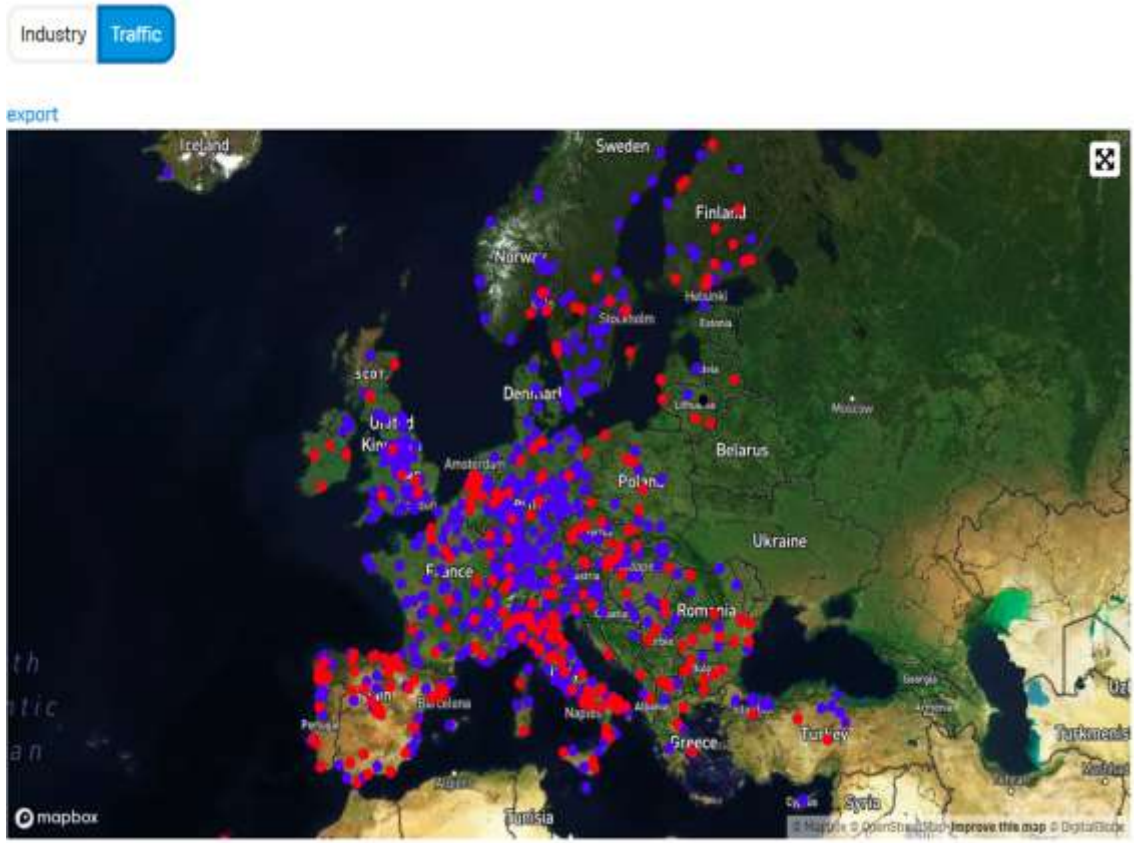
- **GIS Tool to support macroscale and microscale siting criteria**

  – Interactive tool to check distance to sources

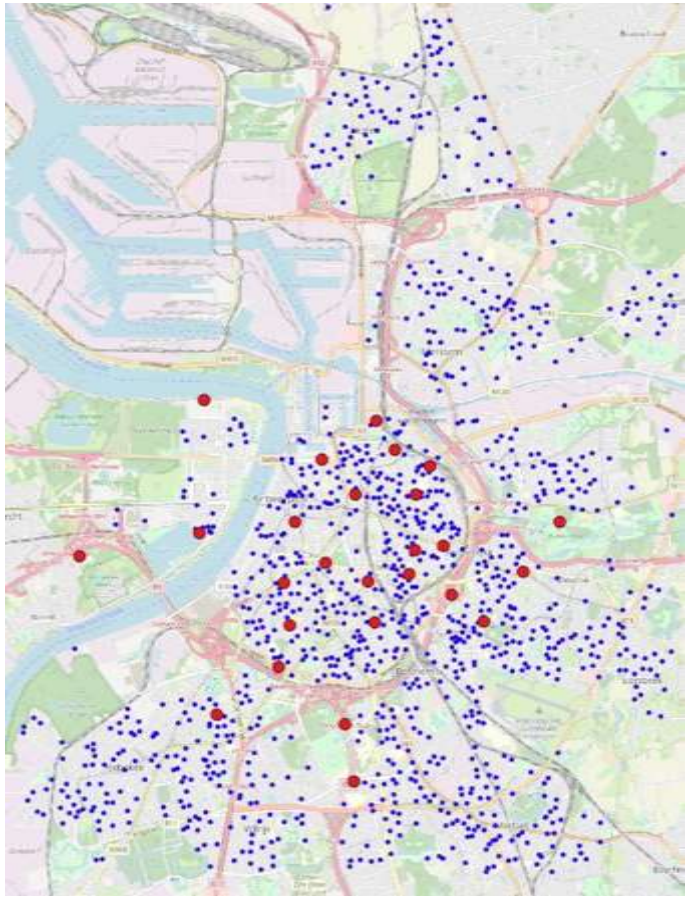
  Designed to investigate whether the given location of a sampling point is in line with two specific siting criteria under the macroscale and microscale criteria in Annex III, - **related to station representativeness**

  - For traffic-oriented sites, sampling probes shall be at least 25m from the edge of major junctions and no more than 10m from the kerbside. (Microscale siting, Annex III C).
  - For industrial sites, sampling points must be sited in such way that the air sampled is representative of air quality for at least an area of 250m x 250m (Macroscale siting, Annex III B (c)).

  – Possibility of further development



Tier 2 – sampling campaigns



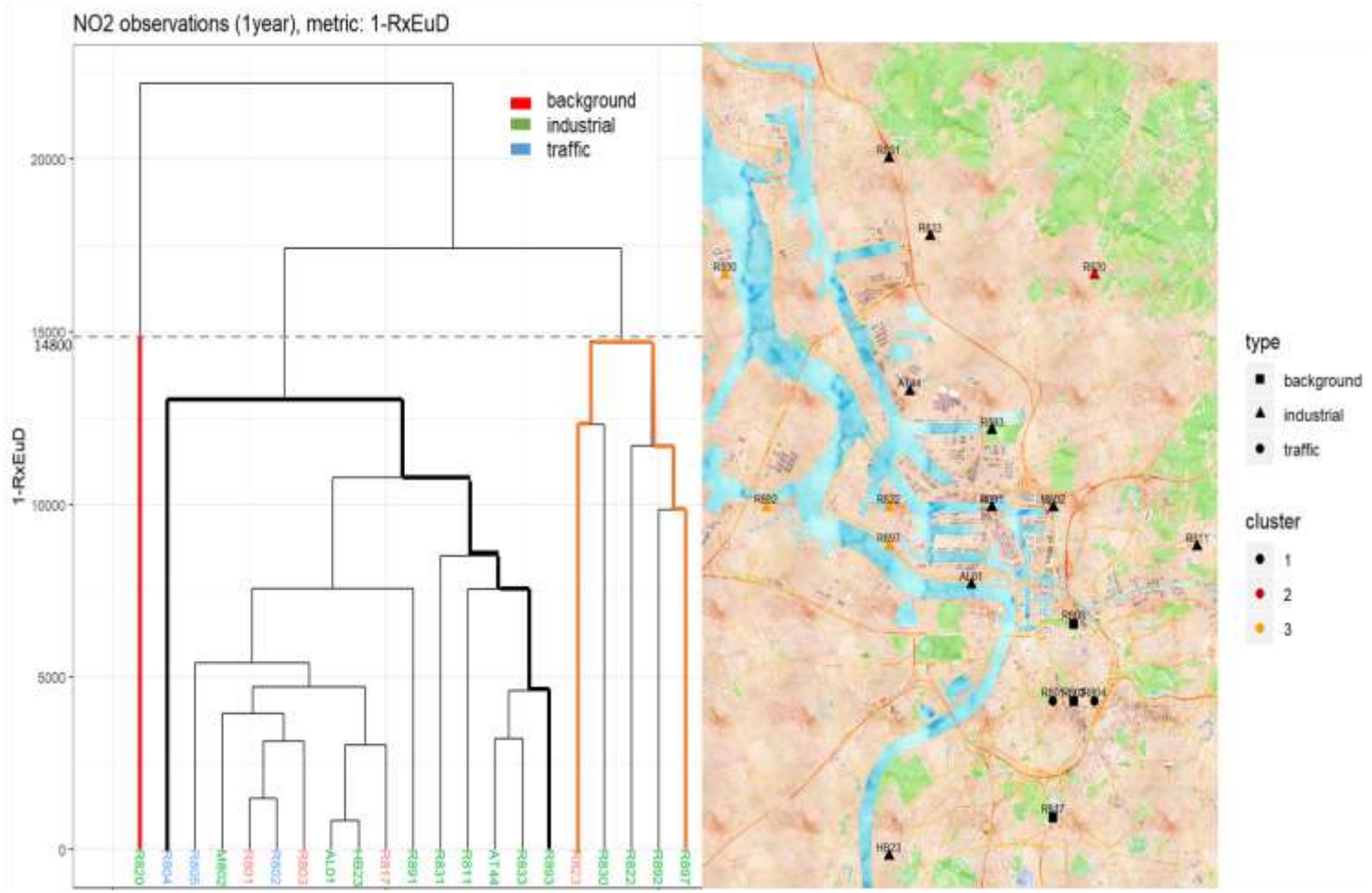
NO_2 passive sampler campaign in Antwerp.

- Red dots indicate the locations of the VMM samplers,
- Blue dots indicate the locations of the participants in the Curieuzeneuzen citizen science campaign.

Sampling campaigns – microsensor deployment – can be useful to

- Identify “hot-spots”
- Characterize spatial representativeness of existing networks
- Enhance the number of observations for model validation

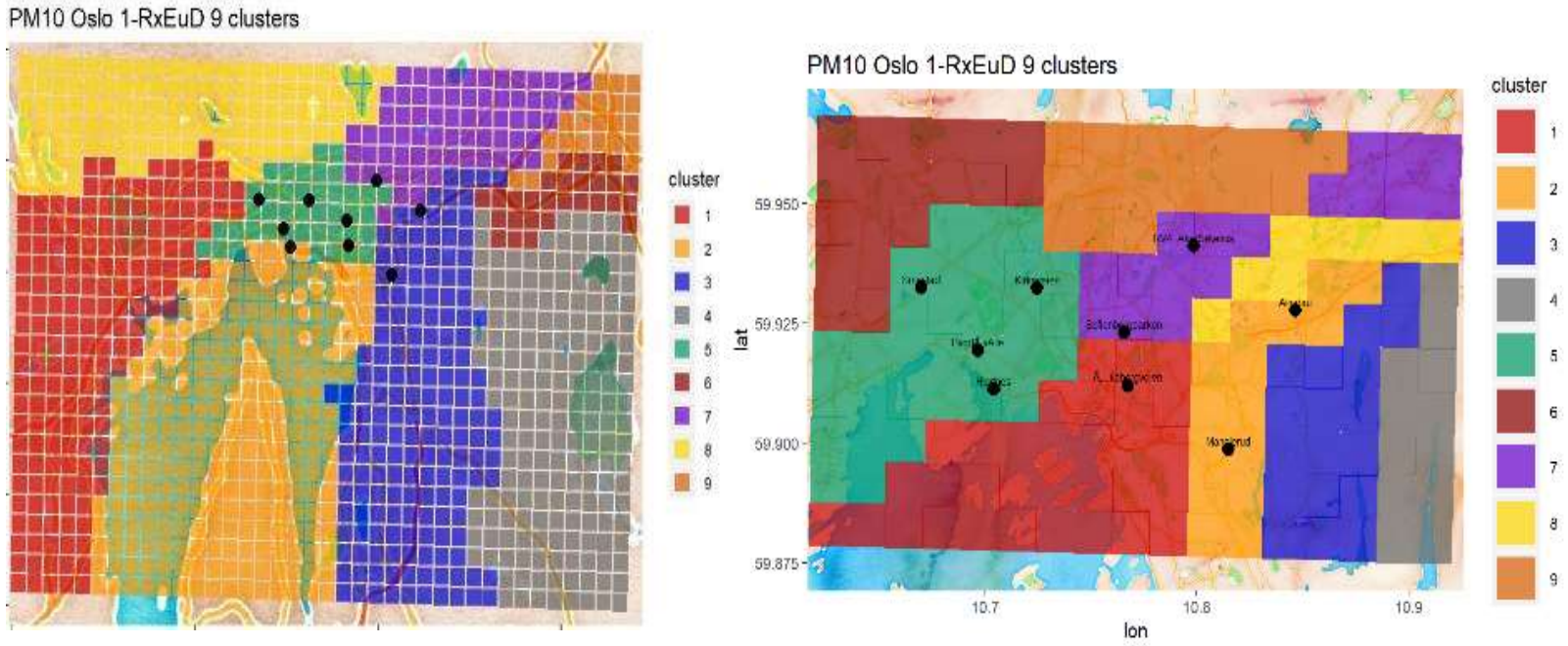
Tier 2 – Clustering approach for Monitoring Design



NO_2 - Antwerp.

- The clustering approach allows the identification of sampling points with similar behaviour
- Allows identification of redundancies in the network
- Allows identification of “outliers” in the clustering analysis
- It is not an excluding exercise but a screening approach to identify different behaviours that need to be further investigated.

Tier 3 – Clustering approach for Monitoring Design



SR Clusters for PM_{10} in Oslo in 2015.The position of the monitoring sampling points are given as black dots.

- The hierarchical clustering methodology can be used to actively support monitoring network design activities at local and national level.
- Used for **all grid points in the modelling domain** to identify clusters of similarity with respect to modelled air quality situations .
- Clusters of similarity to identify redundancies in the monitoring network as well as gaps

Suitability of Tiered approach

		SR area of sampling points (based on annual mean concentrations)	Exceedance Situation indicators (area, no. of people, road length)	Design of monitoring network	Sampling points for model calibration and validation
Tier 1	Expert Opinion	• Only for (urban) background sampling points • Not recommended for traffic sampling points • Unclear for industrial sampling points	• Not recommended	• Significant gaps related to the evaluation of "representative area" of sampling points	• Significant gaps related to the evaluation of "representative area" of sampling points
Tier 2	Proxy Information	• Only for (urban) background sampling points • Not for traffic sampling points • Unclear for industrial sampling points	• Not recommended	• Screening methods for sampling point classification • Clustering methodology - Use of dendrograms to identify redundancies and outliers	• Screening method for sampling classification • Clustering methodology - Use of dendrograms to identify redundancies and outliers
	Sampling campaigns	• For all sampling points, if the campaign is well-designed and contains enough sampling locations	• Can be used for number of people exposed to exceedances, if the campaign is well-designed and contains enough sampling locations • Unclear for other indicators due to an absence of available methods.	• Can be effective to support screening methods depending on design of the campaign	• Can be effective to support screening methods depending on design of the campaign
Tier 3	Geographically explicit, comprehensive fit-for-purpose modelling	• For all sampling points, if the model is fit-for-purpose	• For all indicators, but sensitive to methodologies and model errors	• Hierarchical clustering - SR clusters can be used to identify network redundancies and gaps • (-) Data demanding (hourly data in high resolution) • (+) Can support spatial representativeness analysis for purposes beyond monitoring design	• Clustering methodology - provides additional evaluation of temporal variability • (+) Use of dendrograms to QA/QC model performance
Tier 4	Modelling complemented with dedicated measurements	• For all sampling points, if the methodology is fit-for-purpose	• For all indicators, but sensitive to methodologies and model errors	• Can be useful when combined methodology is fit-for-purpose	• Can be useful when combined methodology is fit-for-purpose

Summary and Relevance

- The work will recommend adoption of and guidance development for higher tiered approaches to estimate SR
  - Bringing Europe more in line with the UK approach
  - Important for exposure and health impact assessment – particularly PM2.5
- Demonstrates the benefits of diffusion tube monitoring to support automatic monitoring and improve accuracy of SR calculations
- Street canyons are important when considering calculations of exposure
- Developing tools which may be very useful to support network design
- One of a number of projects supporting the Commission in their work to improve and update provisions in the AQDs

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Technology

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Interim reports available: https://fairmode.jrc.ec.europa.eu/exposure.html